

**FAA Approval Apollo TSO C129 GPS
Follow-on Installations**

April 29, 1996
Part #: 560-0922-00

II Morrow Inc.
2345 Turner Rd. SE
Salem, OR 97302

II Morrow, Inc.

**Apollo TSO C129 GPS
Follow-on Installations
FAA Approval Procedures**

Document Number: 560-0922-00

Document Revision: -
April 29, 1996

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| FAA Approval Apollo TSO C129 GPS Follow-on Installations | | II Morrow Inc. 2345 Turner Rd. SE Salem, OR 97302 |
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| Revision Log | | | | | | |
|--------------|----------|--------------------------------------|----|----|--|------|
| Rev | Date | Description | EN | By | | Date |
| - | 04/29/96 | Initial release. Microsoft® Word 6.0 | | | | |

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1. GENERAL

1.1 ABOUT THIS DOCUMENT

This document was created from the guidelines an FAA document AC 20-138, "Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for use as a VFR and IFR Supplemental Navigation System." Comments or remarks contained in brackets, "[text-in-brackets]," when inserted among guidelines reprinted from the AC, have been inserted by II Morrow to provide information about how the related AC 20-138 requirement is met for installations of II Morrow Apollo equipment.

1.2 APOLLO NMS DESCRIPTION

The Apollo NMS is a TSO C-115b multi-sensor navigation management system including TSO-C129 GPS. It provides for connection to an external annunciator/switch array, and it receives either pressure altitude or corrected baro altitude data from an existing source on the aircraft. It may also use optional TSO-C60b Loran-C sensors, and it may receive fuel and airdata information from an optional fuel/airdata computer. The Apollo NMS can drive a dedicated display such as a CDI/HSI, or it can be coupled to a shared HSI/CDI and autopilot system using navigation source selectors and annunciators. The Apollo NMS is authorized for VFR/IFR enroute oceanic and remote, enroute domestic, terminal, and non-precision approach (GPS, Loran-C, VOR, VOR-DME, TACAN, NDB, NDB-DME, RNAV) operation.

1.3 INITIAL AIRWORTHINESS APPROVAL

The Apollo NMS system is TSO authorized under TSO C129 A(1), B(1), and C(1) as a GPS system. It is also authorized under TSO C115b as a multi-sensor system having all the privileges of TSO C129, but also allowing other sensors to be used in the system. TSO authorizations mean that a product is an approved airplane replacement or modification part and that the design meets the TSO requirements, but a TSO does not imply or give a product any airworthiness approval.

Airworthiness approval for any equipment may be obtained via the Type Certificate (TC), Supplemental Type Certificate (STC) processes or for an individual aircraft via the FAA form 337 process.

Initial airworthiness for any GPS equipment must be via the TC or STC process. II Morrow has obtained this initial airworthiness approval in the form of FAA **STC SA00328SE**.

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1.4 FOLLOW-ON AIRWORTHINESS APPROVAL

1.4.1 Identical Installations

If an identical installation to that which has been approved via the STC process is done in an aircraft model or type that is listed on the STC or an approved model list (AML) for that STC, no further FAA approval is required. The installation must be made according to the STC data, and a 337 should be submitted as a record of the alteration. The AFM supplement or Supplemental Flight Manual listed on the STC or the AML should be used.

1.4.2 Follow-on Installations

If an installation is not identical, or if the installation is made in another type aircraft, FAA approval of the installation should follow the guidelines contained in FAA document AC 20-138 for follow-on airworthiness approval. Follow-on approval may be obtained either by the TC/STC process, or via the FAA form 337 process (the most common way).

For any follow-on installations not identical to that approved for the STC, the original airworthiness approval, STC SA00328SE, shows that the equipment meets airworthiness requirements. It is then necessary to provide sufficient data to show that the installation also meets airworthiness requirements, and the FAA form 337 then becomes the approval of the data for that installation in that specific aircraft. For follow-on IFR installations, a Flight Manual Supplement or Supplemental Flight Manual should be prepared by the installer. It must be approved by the FAA for that airplane. The limitations section should be identical (or more restrictive) to that contained in the one approved for the STC.

Note: If a system is installed such that it is limited to enroute and terminal operations only, an AFM limitation: "Not authorized for approach operations" might be substituted for all other approach limitations listed in the AFM.

The other sections may be modified as required to reflect the details of the specific installation (how to select it as the navigation source for the primary CDI/HSI, etc.).

2. FOLLOW-ON APPROVAL VIA THE FAA FORM 337 PROCESS.

2.1 GENERAL

Data approved for the STC, although not approved data for models or types of aircraft not listed on the STC or associated AML, are usually considered acceptable data as applicable to follow-on installations. This would include all installation manuals which are approved STC data. Other acceptable data might include sections of FAA AC 43.13-1A or AC 43.13-2A as applicable to the installation as well as a description of any changes or deviations made to the previously approved data. The guidelines in this document are taken from the guidelines contained in FAA document AC 20-138, "Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for use as a VFR and IFR Supplemental Navigation System." A similar document, AC 20-130a, intended for multi-sensor system installations, may also be used when the installation uses Loran-C sensor(s), air-data

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computers, or other non-GPS sensors which have not been previously approved in the aircraft as a part of this installation.

2.2 PRELIMINARY

The 1st step to obtaining follow-on approval via the FAA form 337 process is to coordinate with your local FSDO. Especially if you have not done a similar installation approved through this FSDO before, we recommend that you contact your FAA FSDO, describe what you intend to do and how you intend to proceed, and obtain concurrence from your FSDO with your plan. You may wish to provide the FSDO with a copy of this document and the Supplementary Airplane Flight Manual if your plan is to follow the steps described here, and ask them if there are any changes or alterations they would like to the process described here. This step can help avoid any misunderstandings or even worse, an aircraft that can not be returned to service in a timely manner. We also recommend that you obtain a copy of FAA document AC 20-138, "Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for use as a VFR and IFR Supplemental Navigation System."

2.3 VFR INSTALLATIONS

Installations limited to VFR should follow the guidelines in AC 20-138 paragraph 7c., VFR Airworthiness Approval. When installing an Apollo NMS to be limited to VFR operations, follow the installation manual procedures and verify that under "Install Options", "IFR?" is set to "no."

The remaining follow-on installation criteria is from AC 20-138, paragraph 7.c.(2), Follow-On VFR Airworthiness Installation Approvals.

2.3.1 VFR Data Requirements

7c(2)(i) Unless otherwise provided, contact either the manufacturer or the organization responsible for obtaining the first-time airworthiness approval of the equipment in order to:

- (A) Obtain a sample airplane or rotorcraft flight manual supplement (or supplemental flight manual) **if required for the aircraft.**

[Note: AFM supplements are generally not required for installations limited to VFR use. The required limitations are in the form of the placard that states "GPS limited to VFR use." AC 20-138 Paragraph 9.a, Flight Manual Supplement, says: "...A Flight manual Supplement or Supplemental Flight Manual **may** be required for installations limited to VFR use only, depending on the complexity of the installation and the need to identify necessary limitations and operating procedures."

The GPS equipment doesn't require one, but the particular installation might require one if the installation requires complex switching or non-intuitive selection or operation. These would then need to be described in the operating procedures section of an AFM.]

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(B) Obtain Verification of the equipment approval status, including antenna, software, autopilot/flight director interface, system integration requirements, etc.

[The Apollo 2001/2101 systems, including the A-33 antenna, Apollo 2022 remote GPS sensors (when used), and the Apollo 2002/2102 Keypad/GPS-sensor (2101 dzus configurations only) are manufactured under, and have received design approval, under FAA TSO authorization. Each unit has an identification tag that identifies the TSO(s) under which it has been authorized. The equipment has received initial airworthiness under STC SA00328SE.]

(C) Verify that the maximum operating speed for which the GPS equipment is qualified is compatible with the maximum expected groundspeed of the equipment.

[The Apollo NMS is rated for maximum groundspeed of 999 kts].

7c(2)(ii) Conduct a similar data evaluation as outlined in 7c(1)(ii) of this AC: (following requirements are from AC 20-138 7c(1)(ii))

(A) Review the equipment installation in the aircraft.

(B) Verification that the equipment is appropriate to the aircraft environment in which it is installed.

[DO-160 environmental qualifications are in the Installation Manual]

(C) Verification that the installation of the GPS equipment, including antenna, is sufficient to meet all structural mounting, dynamic, and emergency landing loads appropriate to the aircraft.

[Refer to the antenna installation manuals, AC 43.13-1A and or AC 43.13-2A as appropriate, and/or other acceptable data.]

(D) Verification that a placard stating: “GPS limited to VFR use only” is installed in clear view and readable by the pilot.

(E) Verification that the GPS equipment installation does not interfere with the normal operation of other equipment installed in the aircraft.

2.3.2 VFR Flight Test Requirements

7c(2)(iii) Conduct a functional flight evaluation covering the items specified in paragraph 7c(1)(iv) of this AC.

Note: Required flight evaluations for follow-on equipment installations approved via the FAA form 337 process may be conducted by the installer.

(The following items are from AC 20-138, paragraph 7c(1)(iv)).

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(A) Evaluation of installed GPS navigation system to verify that it is functioning properly, safely, and in accordance with the manufacturers specification.

[use the post installation check-out procedure provided in the installation manual]

(B) Evaluation of steering response while the autopilot and/or flight director is coupled to the GPS equipment during a variety of different track and mode changes. All available display sensitivities should be evaluated.

[This is not applicable if the GPS is not interfaced to the autopilot and/or flight-director]

(C) Evaluation to verify that the GPS equipment does not adversely affect OTHER onboard equipment (this test may be partially accomplished as a ground test).

[Note that the comm transmitter frequency interference to GPS test is not required for installations limited to VFR - it is only required for IFR installations. It is good practice to check VFR installations for interference caused by comm transmitters even though it is not required]

(D) Validate navigation system accuracy by at least 5 low altitude overflights of one or more surveyed locations (ensure survey point coordinates are relative to WGS-84 or NAD-83). An acceptable method of conducting this accuracy demonstration is to accomplish low-altitude (less than 100 feet AGL) overflight of a runway threshold and record the GPS position as the aircraft crosses the threshold. The system accuracy is the distance between the coordinate position determined by the GPS and the coordinate position of the surveyed location (runway threshold) Runway threshold coordinates may be obtained by the airport operator. If coordinate data conversions to WGS-84/NAD-83 is necessary, contact the National Flight Data Center at (202) 267-9277.

[During the flight test conducted for the initial airworthiness this was accomplished by creating a user waypoint as the threshold was passed. To do this press db. The create user waypoint by lat/lon page will be displayed. As the threshold is crossed, press ENT. A waypoint will appear with the current lat/lon position. Press ENT to save the waypoint. You can change the name of the waypoint before saving it or record the automatic numeric name assigned prior to saving so that you can retrieve it later. Total allowable position fixing error from AC 20-138 6a(1) is 0.124 nmi.]

(E) Evaluation of the accessibility of all controls pertaining to the GPS installation.

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(F) Evaluation of the visibility of the controls, displays, and annunciators relating to the GPS installation during day and night lighting conditions. No distracting cockpit glare or reflections may be introduced and all controls must be illuminated for identification and ease of use. Night lighting shall be consistent with other cockpit lighting.

[Note: the automatic dimming display of the equipment was evaluated by the FAA flight test branch for initial airworthiness; however, it is important to verify that the dimming circuits for any annunciators are working properly so that they will be readable, without being blinding under both day and night operations. You should also verify that the equipment is not mounted such that displays or controls are obscured.]

2.4 IFR INSTALLATIONS

Guidelines contained in AC 20-138, paragraph 8c(2), Follow-on IFR Airworthiness Installation Approvals, is appropriate for obtaining FAA approval of follow-on IFR installations. For all IFR installations, follow the system set-up instructions contained in the installation manual. Follow the procedures and verify that under “Install Options”, “IFR?” is set to “yes.”

The Apollo NMS may be installed for GPS C129 approach operations or the installation may be limited to enroute/terminal only. If the installation is limited to enroute terminal only, follow the system set-up instructions contained in the installation manual. Follow the procedures and verify that under Install Options, IFR? is set to “yes,” and APPR? is set to “no.”

2.4.1 Field Approval of the Data

For IFR installations, it is especially important that the installer and the FAA person or office that will be approving the installation data agree on the requirements and the approval process before the installation is performed. The normal process for obtaining follow-on installation data approval is as follows:

1. Contact your FSDO or FAA airworthiness inspector and explain what you intend to do and how you intend to proceed. Tell them exactly what data you intend to submit for their approval. Ask your FSDO to concur with your plan or to offer guidance as appropriate.
2. Use the II Morrow initial airworthiness approval, STC SA00328SE, as a basis for your follow-on installation and as proof that the equipment has obtained initial airworthiness approval.
3. Prepare an FAA form 337, listing STC SA00328SE as the previous approval source of STC data which will be used, such as installation manuals. List any changes or alterations to this data, and list other appropriate acceptable data used, such as that found in FAA ACs like 43.13-1A or -2A.
4. Submit the FAA form 337, along with any data listed on the 337 which the FAA may not have readily available to them, a copy of the AFM supplement approved by the

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- ACO for the initial airworthiness, and an AFM supplement prepared for the subject aircraft (see Appendix B of this document). A flight test plan meeting the conditions of AC 20-138 8c(2)(iv) may be among the data required by the FSDO for follow-on installation approval.
5. The FAA FSDO will then normally review the data, and approve it for that installation (Field approval of the data as evidenced by FAA signature in block 3) as well as approve the proposed AFM supplement based on its similarity to one approved for the STC.
 6. The 337, which then approves the data for installation in that aircraft, is returned to the installer. The installer then completes the installation, signs the statement of conformity with the data (Block 6), and returns the aircraft to service. Note that if a flight test plan was part of the data approved for the installation, the conformity statement in block 6 also means the aircraft was successfully tested in accordance with that plan.
 7. The completed FAA form 337 is returned to the FAA. A copy of the 337 and its associated data go to the aircraft records.

2.4.2 IFR Data Requirements

The following guidelines, from AC 20-138 8c(2), assume that the equipment is installed for approach operations. If limited to enroute/terminal, ignore those items related only to approach equipment.

8c(2)(i) Unless otherwise provided, contact either the manufacturer or the organization responsible for obtaining the first-time airworthiness approval of the equipment in order to:

- (A) Obtain a sample airplane or rotorcraft flight manual supplement (or supplemental flight manual if appropriate)

[A sample AFM Supplement is available from II Morrow, P/N 561-1045-00]

- (B) Obtain Verification of the equipment approval status, including antenna, software, autopilot/flight director interface, system integration requirements, etc.

[Note: The Apollo 2001/2101 systems, including the A-33 antenna, are manufactured under, and have received design approval, under FAA TSO authorization. Each unit has an identification tag that identifies the TSO(s) under which it has been authorized. The equipment has received initial airworthiness under STC SA00328SE. You can verify that the part numbers on the Apollo equipment are found listed in the configuration index data approved for the STC.]

- (C) Discuss any problem areas and seek assistance in their solution.

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[Contact II Morrow technical support at (800) 525-6726 or (503) 581-8101 if you require any assistance in this area].

(D) Verify the design maximum operating speed for the GPS equipment is compatible with the maximum expected ground speed of the aircraft.

[Apollo NMS GPS is design limited to 999 knots]

8c(2)(ii) If the aircraft is approved for flight in known icing conditions, verify the suitability of the antenna installation in accordance with the guidance specified in paragraph 8b(7) of this AC.

Paragraph 8b(7) reads: Anti-ice Protection. If the aircraft in which the GPS equipment is installed is approved for flight into known icing conditions, the antenna must be found not to be susceptible to ice buildup (i.e. is installed in a non-icing location on the aircraft, or is of a sufficiently low profile that ice does not accumulate on the antenna). Alternatively, the GPS equipment can be shown to operate satisfactorily when the antenna is subject to icing provided there are no harmful effects such as possible ingestion of accumulated ice or degradation of the aerodynamic performance. (The affects of ice accumulation, if any, can be found in the manufacturer's installation instructions.)

8c(2)(iii) Conduct a data evaluation similar to that outlined in paragraph 8c(1)(ii) of this AC.

The following is extracted from AC 20-138 8c(1)(ii)

(A) Review of installation drawings, wiring diagrams, and descriptive wiring routing.

(B) Evaluation of the cockpit layout of the installed equipment with emphasis on equipment controls, applicable circuit breakers (labels and accessibility), switching arrangement, and related indicators, displays, annunciators, etc.

(C) Analysis of a data flow diagram in order to review which equipment provides what data to which other equipment.

(D) Review of a structural analysis of the equipment installation, including antenna, in order to ascertain whether structural mounting, dynamic, and crash load requirements are satisfied.

[Refer to the antenna installation manuals, AC 43.13-1A and or AC 43.13-2A as appropriate, and/or other acceptable data.]

(E) Review of an electrical load analysis in order to verify that the total electrical load requirements are within the capabilities of the aircraft's electrical generating system. Determine that the supplied electrical power is consistent with applicable equipment reliability requirements.

[Refer to STC Master Drawing List, P/N 560-0920-00 (or later approved revision), section 4.5: "An electrical load analysis, such as described in AC 43.13-1A, Chapter 11, section 2, should be performed on each aircraft."]

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(F) Verification that the aircraft environment in which the GPS equipment is installed is appropriate to the environmental categories (or criteria) in RTCA/DO-160C to which the equipment has been tested.

[Apollo NMS DO-160c environmental qualifications are contained in the installation manual for each Line Replaceable Unit (LRU)]

(G) Evaluation of the antenna installation. It is important that the antenna be one that is approved for the particular type of GPS equipment installed. A critical aspect of any GPS installation is the installation of the antenna. Adequate isolation must be provided between the GPS antenna and any other transmitting antenna(s) installed on the aircraft. Shadowing by aircraft structure can adversely affect the operation of the GPS equipment. Typically, a GPS antenna is located forward of the wings on the top of the fuselage to minimize effects of the wings, tail, etc. during aircraft maneuvering. For installations on helicopters, the effects of the rotor blades on antenna performance must be considered.

NOTE: The GPS signal is typically below the value of the background noise. Electrical noise in the vicinity of the antenna can adversely affect the performance of the system. Antenna installation in close proximity to traffic alert and collision avoidance system (TCAS), satellite communication (SATCOM), and other transmitting antennas (particularly "L" band) should be carefully evaluated for potential mutual interference.

[The Apollo A-33 antenna is approved under the STC data for use with the Apollo NMS system. The STC Configuration Index, P/N 560-0919-00 (or later FAA approved revision) lists part-numbers and documents approved for use with this STC. Not all TSO authorized antennas are approved for use with any IFR authorized GPS - only antennas identified in the STC data may be used]

2.4.3 IFR Flight Test Requirements

8c(2)(iv) Conduct a functional flight evaluation covering the following items

- (A) Overall operation of the GPS equipment, including interface with other equipment in the aircraft.
- (B) The effects of GPS equipment failure (open circuit breaker) including autopilot/flight director response if applicable.
- (C) If interfaced with an autopilot and/or flight director, steering response while the autopilot and/or flight director is coupled to the GPS equipment.
- (D) Displayed GPS navigation parameters on all interfaced cockpit instruments.

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(E) The effect(s), if any, of switching and transfer functions, including electrical bus switching, pertaining to the GPS installation.

(F) Evaluation to determine satisfactory electromagnetic compatibility (EMC) between the GPS installation and other equipment as specified in paragraph 8c(1)(iv)(F) of this AC.

NOTE: Verification of adequate isolation from harmonic interference of VHF communications transceivers is required for installation of GPS navigation equipment in each individual aircraft. This test should be repeated if a VHF transceiver is replaced or added, or if a new or replacement VHF communications antenna is added.

[Requirements (A) and (F) and significant portions of other flight test requirements are satisfied if the post-installation check out procedure from the installation manual is completed. It need not be verified again if the post installation check-out is identified as part of your flight-test procedure. Note also that a post-installation check-out log is provided in the installation manual and may be included in your flight-test results]

(G) Accessibility and visibility (day and night conditions) of all controls pertaining to the GPS installation.

[Note: For the initial airworthiness flight test, night visibility was evaluated as a ground test by simulating night lighting conditions: The aircraft windows were covered with aluminum foil attached with black electrical tape; night illumination of annunciators and displays were then evaluated.]

(H) Validate GPS accuracy in each operation mode as specified in paragraph 8c(1)(iv)(J) of this AC.

[During the flight test conducted for the initial airworthiness this was accomplished by creating a user waypoint as the threshold was passed. To do this press db. The create user waypoint by lat/lon page will be displayed. As the threshold is crossed, press ENT. A waypoint will appear with the current lat/lon position. Press ENT to save the waypoint. You can change the name of the waypoint before saving it or record the automatic numeric name assigned prior to saving so that you can retrieve it later. The operation modes for the Apollo NMS correspond to the mode buttons on the front panel; they are: MSG, EMG, NAV, DB, FPL, and SYS. By design analysis, the data supplied to external displays in any equipment operational mode is the same as that supplied when the equipment is in NAV mode. Flight test accuracy need only be evaluated in NAV mode. Total allowable position fixing error from AC 20-138 6a(1) is 0.124 nmi. for enroute and terminal operations and 0.056 nmi. for Approach operations.]

(I) Verify continuity of navigation data during 360 degree left and right turns at 30 degrees of bank.

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(J) Monitor displayed cross-track error during en route, and if applicable, approach transition and approach operations to verify FTE is less than 1.0 nmi (en route and approach transition) and 0.25 nmi. (approach), both with and without the use of autopilot and flight director (if installed).

[Flight Technical Error (FTE) may be observed by navigating to a known waypoint such as a runway threshold or a VOR. Fly the airplane as “on-course” as possible using the cross-track deviation displays. Note when the Apollo NMS indicates that you have crossed the waypoint (first suspend waypoint sequencing by pressing OBS/HLD. When the “to/from” flag flips to the “from” state then the Apollo NMS is indicating crossing of the waypoint) Visually confirm that the waypoint is within the allowable limits for FTE as stated in (J) above]

(K) For equipment approved for approach, conduct at least three published instrument approaches (retrieved from the database) to verify proper operation of the equipment in the approach environment.

NOTE: Required Flight Evaluations will be conducted by the cognizant Aircraft Certification Office (ACO or, when authorized, by a flight test pilot designated engineering representative (DER) in accordance with the procedures used by the cognizant ACO. Depending on the level of similarity between the initial and the follow-on installations, including aircraft type, the ACO may accept flight evaluations conducted by the installer.

2.5 SAMPLE AFM SUPPLEMENT

A sample AFM Supplement based on one approved for the STC is available from II Morrow Inc. When submitting a prepared AFM supplement or Supplemental Flight Manual to an FAA FSDO for approval, you should always send a copy of the FAA Aircraft Certification Office (ACO) approved manual on which your supplement is based. This allows the FSDO to compare your manual with one previously approved for the equipment. Without a copy of the previously approved manual, the FSDO has no way to determine whether your submitted manual is close enough to that previously approved to allow the FSDO to approve your changes without referring it to the cognizant ACO for further evaluation.

2.6 FLIGHT TEST PLAN

We recommend that you take the flight test requirements from this document and use them as a flight test checklist. This checklist, modified as appropriate for your test area and modified with any changes or specific requirements of your FSDO should be adequate as your follow-on installation flight test plan.

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For VFR installations, the flight test may be performed by the installer; however, we recommend that you first obtain concurrence from your cognizant FSDO with the details of your flight-test.

For IFR installations, the FAA may delegate the flight test to the installer; however, this is at the discretion of the FAA. We recommend that you discuss in advance with your FAA FSDO who will be authorized to perform the flight test, and make the necessary arrangements to accommodate the test.

Many FSDOs will allow your flight test plan to be listed as data on the FAA form 337. If it is listed, then the installer automatically certifies that those flight test conditions have been satisfactorily met when the 337 statement of conformity is signed by the entity authorized under FAR 43 to return the aircraft to service.

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